

IN THE TITLE:

Please amend the title as follows:

~~SYSTEMS, METHODS AND COMPUTER PROGRAMS FOR MONITORING
DISTRIBUTED RESOURCES IN A DATA PROCESSING ENVIRONMENT~~

METHOD FOR MONITORING DATA RESOURCES OF A DATA PROCESSING
NETWORK

IN THE SPECIFICATION:

Please amend the specification as follows:

Page 3, line 15 to page 7 line 25:

~~Aspects of the present invention provide methods, apparatus and computer programs for monitoring resources within a data processing network. Monitoring entities can be selected, and a set of active monitoring functions can be modified, based on the requirements of consumers of monitored data.~~

~~A first embodiment of the invention provides a method for monitoring resources of a data processing network on behalf of consumer entities within the network. The method includes determining the monitoring requirements of a consumer entity (such as by reference to a description of requirements published by the consumer entity). The monitoring requirements of the consumer entity are compared with the monitoring capabilities of a plurality of monitoring entities, to identify at least one monitoring entity having monitoring capabilities matching (partially or completely) the monitoring requirements of the consumer entity. One or more of the monitoring entities identified as having monitoring capabilities matching the monitoring requirements of the consumer entity is then selected, and a connection is established between the selected monitoring entity and the consumer entity.~~

The consumer entity is one of a computer program, a Web service provider, a logical representation (for example, instance of an object class) of an end user, or any physical or logical component of the data processing network which requires monitoring information. Examples of consumer entities are programs implementing resource management functions, implementing load balancing functions, or implementing functions for metering and accounting of resource usage.

The monitoring entities are typically computer program components that perform monitoring functions, although monitoring entities may be implemented in hardware or 'firmware'. Monitoring entities can establish connections to other components, receive and collect output data from a resource, and report the collected data to a consumer entity.

The compared capabilities of the monitoring entities may include one or more of the following: the set of resources currently being monitored by the monitoring entity; the set of resources which the monitoring entity is capable of monitoring; the monitoring metrics which the monitoring entity is currently monitoring; the monitoring metrics which the monitoring entity is capable of monitoring; the current granularity of monitoring; the granularity capability of the monitoring entity; the current monitoring period; the monitoring entity's monitoring period capability; and the data format capabilities of the monitoring entity.

Thus, selection of a monitoring entity may be based on currently active monitoring functions and attributes, and may involve comparing identifiers of the subset of resources and metrics currently being monitored by monitoring entities. Alternatively, selection may be based on the super-set of monitoring capabilities comprising both active and currently inactive monitoring capabilities of the monitoring entities. Selection may involve consideration of the granularity and length of monitoring period desired by the consumer and provided by the monitoring entities. Embodiments of the invention enable selection of monitoring entities for monitoring internal and external monitoring data.

The determining, comparing, selecting and binding may be performed at run time in response to addition of a new consumer entity or a change of consumer requirements.

According to one embodiment of the invention, the comparison uses descriptions of each consumer entity's, monitoring entity's and resource's produced or required data and its data

format. The descriptions are published by the resources, monitoring entities and currently active consumer entities, and are held in one or more repositories. The descriptions of the monitoring entities include which resource instances they are monitoring, which metrics they are monitoring and reporting, and the data format in which they report monitoring data. The repositories also hold a description of the topology of the monitoring system. This topology information includes a list of bindings representing which resources are currently being monitored by which monitoring entities and which consumer entities are connected to receive data from which monitoring entities. When resource instances, monitoring entities or consumer entities change, the lists and descriptions within the repositories are updated dynamically.

A further embodiment of the invention provides a method for monitoring resources of a data processing system, which includes modifying a currently active set of monitoring functions. The method includes identifying the monitoring requirements of a currently active set of consumer entities, and determining whether a currently active set of monitoring functions of monitoring entities are consistent with the monitoring requirements of the currently active set of consumer entities. If a determination is made that the currently active set of monitoring functions are inconsistent with the monitoring requirements of the currently active set of consumer entities, modifications are made to the active set of monitoring functions.

The modification of the currently active set of monitoring functions may involve: controlling a currently active monitoring entity to monitor additional monitoring metrics or to monitor metrics at a different granularity or interval periods; activating an inactive monitoring entity; or deactivating a monitoring function or monitoring entity which is monitoring metrics that are not required by the currently active set of consumers. Such modifications enable dynamic response to the requirements of individual consumer entities. By enabling de-activation of inactive functions or entities, more efficient use of data processing resources is possible.

A further embodiment of the present invention provides a data processing system for monitoring resources of a data processing network. The data processing system includes a data processing unit and a data storage unit for storing monitoring capabilities of each of a set of monitoring entities. The system also includes a monitoring manager which is responsive to monitoring requirements of a data consumer entity. The monitoring manager compares the

monitoring requirements of the data consumer entity with monitoring capabilities of monitoring entities stored in the data storage unit. The monitoring manager identifies and then selects a monitoring entity or a set of monitoring entities having monitoring capabilities matching the monitoring requirements of the data consumer entity.

A monitoring framework comprising a set of monitoring components may be provided at an intermediate layer of a data processing network, between consumers of monitoring data and monitored resources. A monitoring system according to one embodiment of the invention includes at least one gateway component which implements the monitoring manager functions such as handling registration and deregistration of components. The gateway component may support authentication of consumers, and initiate selection of an appropriate monitoring entity (or set) for each consumer entity. The selection may include negotiation between consumers and monitoring entities regarding the monitoring data to be provided (such as when specific requirements cannot be met at a particular point in time). The gateway also initiates binding of monitoring entities to consumer entities.

Upon successful binding between a consumer entity and a monitoring entity, the gateway publishes a description of the binding which is stored within a repository. In alternative embodiments, the matching or selection and binding could be implemented by the monitoring entities instead of the gateway, and functions such as authentication can be performed by additional support modules.

A negotiation between a consumer entity and monitoring entities may specify the action to take when a required metric cannot be monitored for a specific resource during a specific period. Negotiation may involve determining whether a consumer entity's required monitoring QoS parameters can be satisfied by the currently active set of monitoring functions, or by the currently active set of monitoring entities, or by activating new monitoring entities. Monitoring entities may be started at the consumer side to handle re-formatting or other transformation of monitoring data.

A monitoring control method can be used to determine optimal (minimized) computation to generate required data from raw measured data, and optimal transmission frequency, for efficient resource utilization while taking account of the requirements of the

consumer entities. For example, de-registration of a consumer entity may result in a determination that certain monitored metrics are no longer required by any consumer entity such that their monitoring (measurement, collecting and reporting) can be stopped. Selection of a monitoring entity may take account of which of a plurality of monitoring entities can achieve a best match.

Embodiments of the invention may be implemented using computer programs to implement one or more components of the invention. For example, a selector for comparing monitoring requirements with monitoring capabilities to select a monitoring entity, or to modify the active monitoring functions or entities, may be implemented in computer program code. The above described gateways, monitoring entities and support modules may be implemented in program code. The program code may be made available as a computer program product in which the program code is recorded on a recording medium or is made available via a data transfer medium.

The invention includes a method for monitoring data resources of a data processing network on behalf of new consumer. The method comprises determining monitoring requirements of the new consumer. The monitoring requirements include: a list of data resources monitored for the new consumer; metrics of the monitoring data for the new consumer; a data format for monitoring data provided to the new consumer; a time interval between periods of sending the monitoring data to the new consumer; and actions taken during failure of the data resource.

The invention also includes comparing the monitoring requirements of the new consumer with monitoring capabilities of a plurality of monitoring entities to identify at least one monitoring entity, including monitoring capabilities matching the monitoring requirements of the new consumer.

The monitoring entities monitor the data resources of the data processing network. The monitoring capabilities include one or more of: a current set of data resources being monitored by each of the plurality of monitoring entities; a set of data resources which each of the plurality of monitoring entities is capable of monitoring; monitoring metrics which each of the plurality of monitoring entities is currently monitoring; monitoring metrics which each of the plurality of

monitoring entities is capable of currently monitoring; a current monitoring period; and data format capabilities of each of the plurality of monitoring entities. In response to identifying at least one monitoring entity of the plurality of monitoring entities the method includes monitoring capabilities matching the monitoring requirements of the new consumer, selecting at least one of the identified monitoring entities, and binds the new consumer to the selects at least one of the identified monitoring entities.

The binding of the new consumer to the selected at least one of the identified monitoring entities comprises establishing a connection between the new consumer and the selected at least one of the identified monitoring entities, sending a description of the new consumer's monitoring requirements to the selected at least one of the identified monitoring entities, and configuring the selected at least one of the monitoring entities to perform the new consumer's monitoring requirements. In response to a failure to identify at least one of the monitoring entities having monitoring capabilities the method matches all monitoring requirements of the new consumer, the method initiates a negotiation between the new consumer and a plurality of monitoring entities to select a best match, relative to other matches based on quality of service parameters, between the monitoring requirements of the new consumer and the monitoring capabilities of the plurality of monitoring entities.